Experiment (2)

Measuring the Wavelength of Laser with a Simple Ruler

Objective:-

To calculate the wavelength of Laser using a simple ruler as a diffraction grating.

Apparatus:-

He-Ne Laser, metallic ruler, Screen,

Theory:-

Diffraction is the bending of light around the edge of an object. The amount of bending is quite small but depends on the size of the opening relative to the wavelength of the light.

In this experiment, we will use a steel ruler to measure the wavelength of light emitted by a laser. The laser produces a narrow intense beam of monochromatic (i.e., single wavelength) light. The ruler has a shiny, metallic finish. Consequently, if you reflect the laser light off the surface of the ruler, it behaves like a mirror with the angle of reflection equal to the angle of incidence.

Light from a laser has such a high degree of spatial and temporal coherence (what do these terms mean?) that if it is aimed at a steel ruler, the ruler markings can act as a diffraction grating which producing a series of bright spots on the vertical board. The positions of the diffracted beams then enable the wavelength of the laser light to be simply determined.

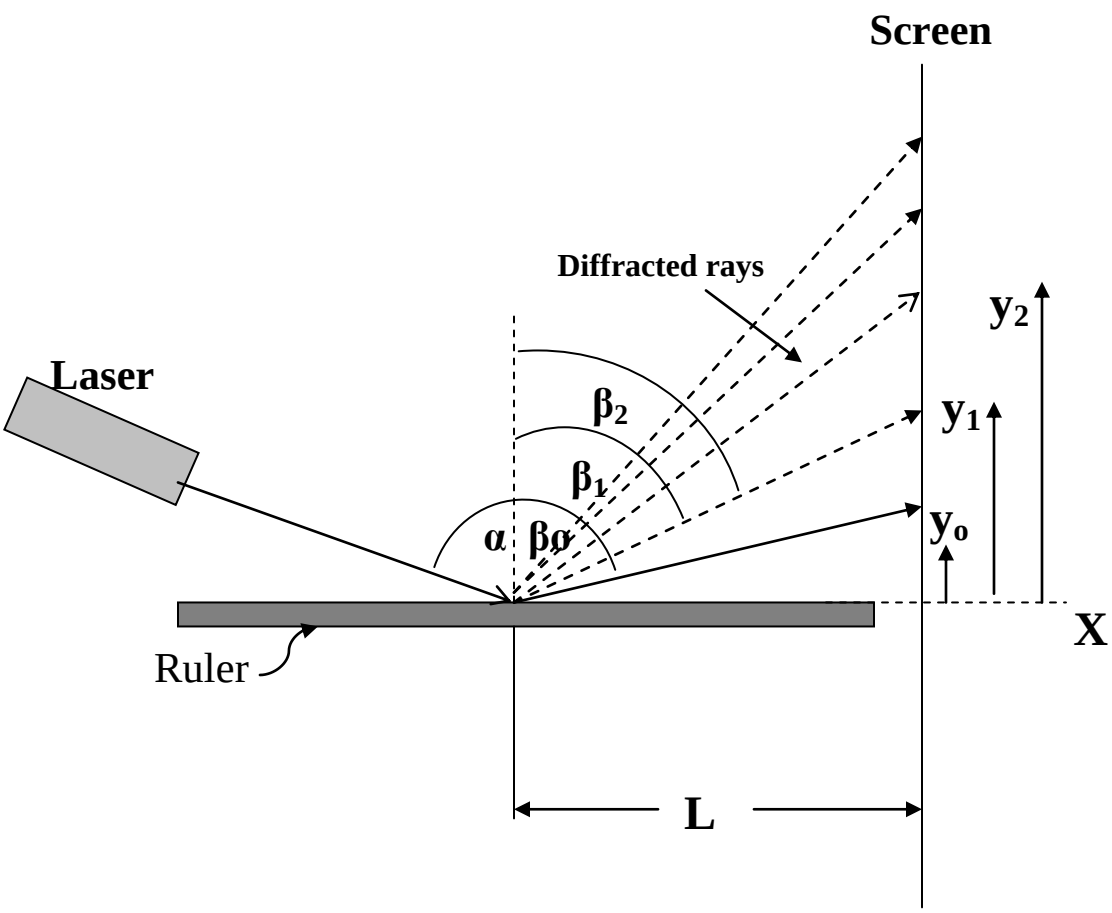

Figure (1): The experimental setup

In this case, the waves are not incident normal to the surface but instead are incident at a small angle and the waves reflect from between the rulings. It is possible for interference to occur.

There will be constructive interference for all pairs of angles **α** and **β** that satisfy the grating equation:

$$n\lambda = d(\sin\alpha - \sin\beta) \quad \ldots\ldots(1)$$

where **d** is the grating spacing, **n** the diffraction order (n=1,2,3,…) and **λ** the wavelength of the laser light.

Now, from simple geometry

$$\beta_n = \frac{x}{\sqrt{x^2 + y_n^2}} \qquad \ldots\ldots\ldots (2)$$

Where $\mathbf{y_n}$ is the height of the $\mathbf{n^{th}}$ diffracted spot.

Provided the spot heights are small compared to the distance to the vertical board, i.e. $y_n << x$, Equ. (2) may be approximated by :

$$\sin\beta_n \approx 1 - \frac{y_n^2}{2x^2} \qquad \ldots\ldots\ldots (3)$$

Therefore, from Equ. (1), and the fact that $\boldsymbol{\alpha = \beta_0}$, we finally have:

$$n\lambda \approx \frac{d}{2}\left(\frac{y_{n-y_0^2}^{2}}{x^2}\right) \; or \; y_n^2 = y_0^2 + \left(\frac{2\lambda x^2}{d}\right)n \quad \text{..... (4)}$$

Procedure:-

1. Assemble the set up according to figure (l).
2. Mount the laser on the magnetic mount in such a way that the beam will make a small angle with the ruler.
3. Record the distance (L) which represent the distance between ruler (where the light striks it) and screen.
4. Record the distance (d) : the smallest distance between neighboring marks on the ruler.
5. Mark on the screen the hight of the spots of light (Y_o ,Y_1 , Y_2 ,….) as shown in figure (l).
6. Plot a graph of Y^2_n against the order of diffraction n.
7. Determined the gradient which equals to $2\lambda L^2/d$ from this you can calculate the wavelenght of laser λ.

Discussion:-

Q1:- Define Diffraction and Explain the Diffraction phenomenon.

Q2:- What are the types of Diffraction.